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DEVELOPMENT OF AN IOS APP FOR LEARNING INTONATION OF WIND INSTRUMENTS

A thesis submitted in partial fulfillment of the
requirements for the degree of
Master of Science

By

SWATHI PAMIDI

B.Tech., Sri Indu College of Engineering and Technology, India, 2016

2018
Wright State University

WRIGHT STATE UNIVERSITY
GRADUATE SCHOOL

April 24, 2018

I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY SUPERVISION BY SWATHI PAMIDI ENTITLED DEVELOPMENT OF AN IOS APP FOR LEARNING INTONATION OF WIND INSTRUMENTS BE ACCEPTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE.

Yong Pei, Ph.D.
Thesis Director

Mateen M. Rizki, Ph.D.
Chair, Department of Computer Science
and Engineering

Committee on
Final Examination

Yong Pei, Ph.D.

Mateen M. Rizki, Ph.D.

Shelley Jagow, Ph.D.

Barry Milligan, Ph.D.
Interim Dean of the Graduate School

ABSTRACT

Pamidi Swathi. M.S. Department of Computer Science and Engineering, Wright State University, 2018. **‘Development of an iOS App for Learning Intonation of Wind Instruments’**.

Learning music instrument is a challenging task for a beginner without constant guidance from an instructor. The primary objective of this thesis research is to design and develop an iOS mobile learning app that helps users to learn and practice intonation for a suite of wind instruments by themselves with comfort and ease through app-provided tuning and charting guidance and app-assisted self-assessment.

Particularly, our successfully-implemented app provides the following features to enhance the user’s learning experience: 1.) provides learners easy-to-access information for the fingering and tuning techniques of wind instruments by converting Dr. Shelley Jagow’s book – “Tuning for Wind Instruments: A Roadmap to Successful Intonation” to an iOS app; 2.) provides instant feedback on learner’s technique and performance by assessing the intonation of individual note being played, while the fingering and tuning chart is presented simultaneously for the early practices; and, 3.) provides instant feedback on learner’s technique and performance by identifying the sequence of notes being played for subsequent practices.

The app is implemented using Xcode and Swift 4.0 and will be distributed through Apple App Store

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I would also like to thank Dr. Shelley Jagow for writing the wonderful book “Tuning for Wind Instruments: A Roadmap to Successful Intonation”. Her continuous help made me eager to learn more about musical instruments and tuning. This helped me complete my project.

I sincerely thank my parents, sister and friends for dealing with my second-hand stress. I appreciate my friends support in enlightening and motivating me from time to time.

I extremely feel happy to be in this University which has given me constant encouragement, hope, and opportunity at every walk. Most of my time I invested on learning as I started from a beginner’s stage in computer science. It also showed me a path that I must build and continue in future.

1. INTRODUCTION

Learning a music instrument is like learning some language. Language learning starts with learning alphabets, where musical instrument starts with learning the level of the frequency or vibration of a note. This frequency is taken as the pitch of sound which can be made by string, wind, electronic, percussion instruments or even by singing through vocal cords.

Playing musical instruments in a pleasant way is an art. Performing perfect music takes many things into consideration like accent, accidentals, acoustics, absolute pitch etc. With constant and consistent practice one can improve their art. Music is a vast area where there are numerous instruments till date. These instruments can be played by an individual or a group of people.

1.1 Fingering and Tuning Charts iOS Application

Music plays a significant role in every field. All expressions, emotions and culture are reflected through music. To learn music, one needs a proper time to time guidance from a person who has knowledge in it. In today's world no one can expect an instructor to guide only you all along the way with group of students in class. But regular practice is a must to achieve the desired performance.

Fortunately, mobile personal technology is growing fast to make knowledge and expertise available to people anytime and anywhere. For example, there are electronic devices and apps that readily give information about everything within seconds. Today, most individual has a smart phone, tablet or iPad within their reach. These devices and apps have many features to help accomplish our learning tasks in a smart and efficient manner.

Most of the time band directors see for perfection when they present music with ensemble. Tuning to the proper pitch with in the group requires much practice. But they don't get enough time to instruct each one in the band to get the perfect result. If there is a technology or an app that can guide as an instructor and gives assessment, musicians can certainly use the help of an application that hears the instrumentalist and performs assessment. By creating a friendly environment and making the learning process simpler and more efficient, either in a group learning or self-learning, learning through app adds little more dedication and determination which may give better results.

Developing application for learning the wind instruments is our initial step. Within the comfort zone, an individual can learn the instrument to get consistent pitch and do the self-assessment on their performance.

This app is implemented in collaboration with Dr. Shelley Jagow using the data from her book "Tuning for Wind Instruments: A Roadmap to Successful Intonation" [1]. This book included everything a music educator requires for the approach for fine tuning intonation with their ensemble and for improvising their knowledge in tuning. Our mobile app allows the user to learn the fine tuning by proper fingering

techniques. It gives an easier way for an individual to refer to the information provided in the book, along the way practice using the application with proper guidance like an instructor standing aside.

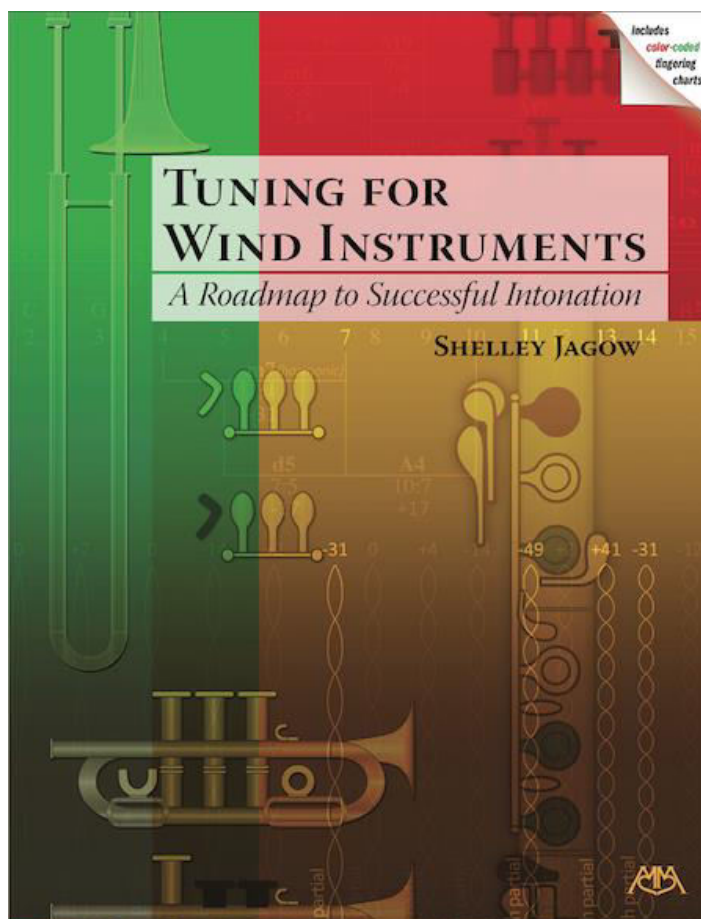


Fig. 1.1. “Tuning for Wind Instruments: A Roadmap to Successful Intonation” by
Dr. Shelly Jagow [2]

1.2 App Design and Development

Creating an application looks like a magic, but there are certain steps that should be done in the background. Any type of application should follow these footprints to get the meaningful results.

Every application follows an SDLC (Systems Development Life Cycle) [3] for designing and developing an application as follows:

1. Planning for the application development
2. Analysis of current applications and functionalities
3. Designing the layout of an application
4. Building the application with basic requirements and according to the guide line
5. Testing and fixing the bugs
6. Implementing the application for public use and monitoring the user experience.

Wind instruments has a typical tube (a type of resonator) that produces vibrations upon blowing air into them. Pitch of the vibrations can be heard at the end of the instrument. Pitch of that vibrations can be controlled by the width and length of the instruments and by manual modifications. In the research carried out on the current app design and development, pitch detection is implemented to assess if the instrument tuning is performed properly using the respective fingering technique. Using different methods to detect the pitch and various view styles, it gives a desired presentation of fingering techniques and evaluation feedbacks to the user.

Our app stands out because of the fingering and tuning material that is been used. It is mainly concentrating on the wind instruments like flute, saxophone, bassoon, clarinet, euphonium, oboe, horn, trumpet, tuba, trombone. The fingering technique details are also taken into consideration. Key charts, tuning notes information, and fingering is provided. Thus, giving a beautiful view to an individual about the

instrument and handing it to get a specific pitch. Alternate fingering is also provided for some notes when available.

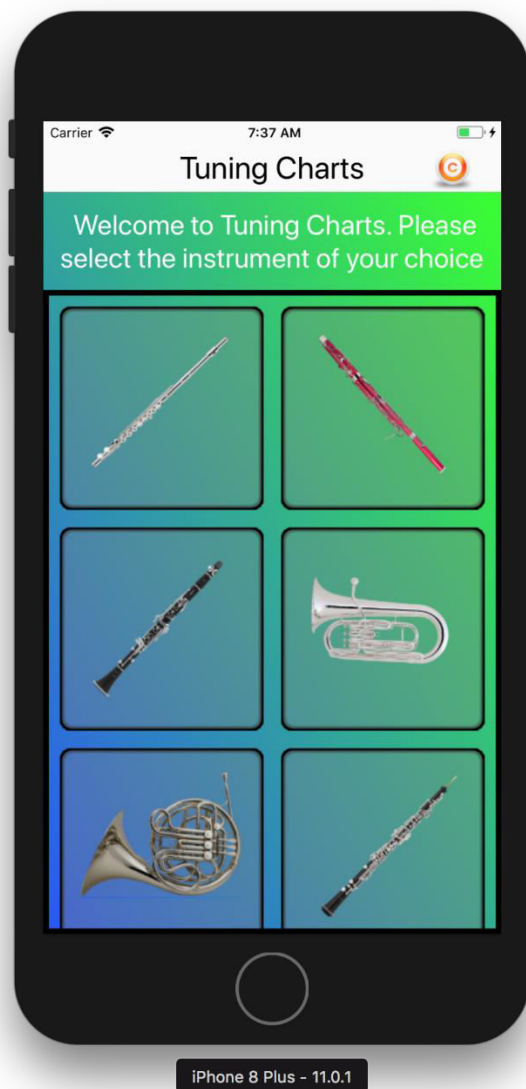


Fig. 1.2. Fingering and Tuning Charts IOS Application

The app starts with a selection page that has ten wind instruments to choose. User can select one of the 10 instruments for learning the detailed instrument, fingering and tuning information. After we go into the detailed view of an instrument, we have

the images of fingering and note images which give the user a broad scope of the instrument handling and their respective note tuning details. Additional information of the instrument is provided in side bar buttons.

A user can see all the details of the instrument before starting to play the notes or while playing. Once user becomes familiar with the instrument note family. User can select the note they prefer to practice. While playing the instrument they can see pitch detection meter that gives an assessment of their performance of that note. It gives an intuitive presentation by using the cents scale in between pitch of notes.

Once the instrumentalist is good at tuning the single note perfectly, he or she can use this app to see the continuous range of notes that they are playing.

To make it easier to incorporate more instruments, we store the related data in JSON file. Quick access to the notes and their fingering or alternating fingering is made possible through a navigation panel at the bottom of screen. All the information about the instrument is mentioned in the side bar buttons. This gives the user a feeling of completeness. Even the tuning/assessing is done in a small pop up window which can be visible while having the normal view at the fingering and related note.

This helps the user to remember the fingering in an effortless way. Tuning is also made more readable by adding the Intonation Meter and using colors as feedback on the performance. For instance, the little tuning window will turn green when pitch analysis indicates correct performance of the selected note. It also shows the cent difference as to be reduced or increased. Other one gives the series of notes as to say how the instrument is tuned. Therefore, its further mechanism can be explained in the following chapters.

2. LITERATURE REVIEW

Thousands of new applications are uploaded in to app store every day. There are numerous applications on fitness, music, gaming, dating, food, and travel on app store. In general, over 15% of the app downloads are done from the music category. This shows how music play a significant role. Music deviates us from the outer world and changes the situations around us.



Fig. 2.1. Numerous IOS Applications on App Store [4]

There are also many applications for learning music through online instruments. However, there are few applications that mainly focused on instrument learning experience. In the Apple App Store or Google Play store, there are some applications on tuning and intonation. Some are really doing a decent job, while some are not. Tuning and intonation-based applications must be accurate to detect the pitch. Concert pitch transposition should be managed properly to not confuse the beginners.

Wind instruments are the one which in general very sensitive to the pitch change, because there are many issues that affect the instruments effectiveness. It starts from how the instrument is handled to how the individual is blowing the wind, the outer disturbances. So, most of the applications mainly concentrated on pitch detection.

Let's see few applications that do a decent job in tuning and fingering [7]:

2.1 Fingering and Tuning Charts for Android

This is an android application that gives complete intonation resource for beginners, band directors and private music instructors, which was the first joint effort between Dr. Jagow and our research group to create an app based on her book.



Fig. 2.2. Fingering and Tuning Charts App Icon

Tuning, fingering and alternate fingering are collected from many years of research from the best in the profession. Select any one instrument from ten instruments (flute, oboe, clarinet, saxophone, bassoon, trumpet, horn, trombone, euphonium, or tuba) [2].

In this application wind instruments have full range of color-coded fingering charts. Scroll the notes to see the respective inherent pitch tendency with fingering image and option buttons are seen if it has any alternate fingering.

Also scroll the fingering charts and see their respective note by selecting the fingering image. This application shows some color like black green and red on fingerings. If it is black it means regular fingering. If it is green it means to add that fingering to instrument while playing that note. If it is red, remove that fingering.

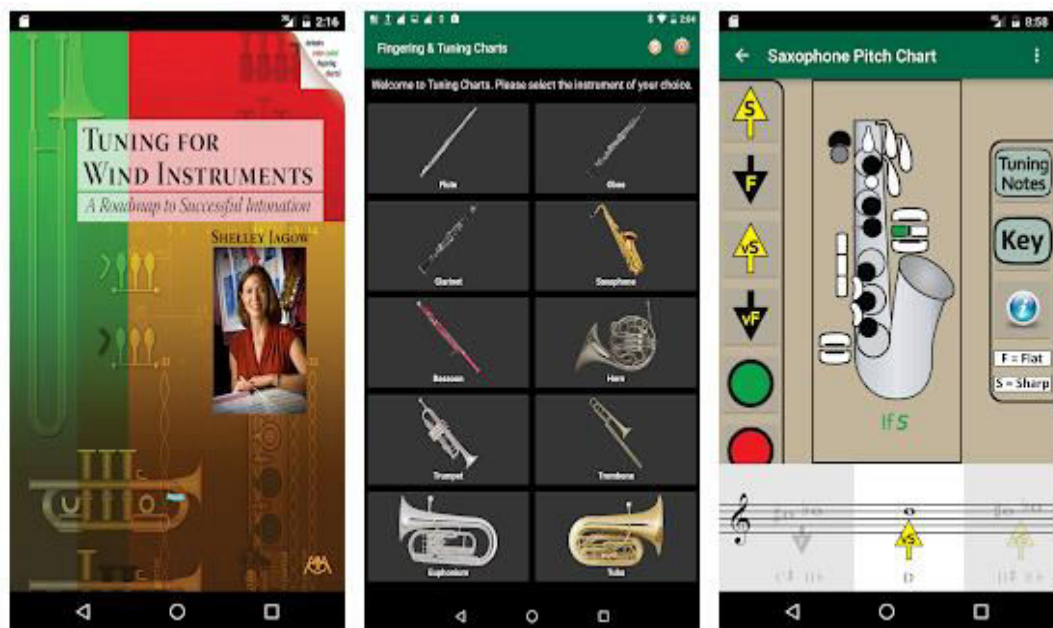


Fig. 2.3 Fingering and Tuning Charts application screens to show its mechanism

Application also shows the best tuning notes for that instrument. Click to show more information about instrument for it in the left and right buttons.

However, the app doesn't provide any assessment capability that give learner feedback, which limits its usage as a comprehensive learning tool.

2.2 TonalEnergy Tuner - iOS Application

This application is a little more than a tuner. This application can be used as a tuner, a recorder, a piano keyboard, strings, and a metronome. It can also play a required pitch to match. One can record the audio or video in it and can listen to it at different speed. It is fun and has practice tools that give feedback for instruments like brass, guitar or any kind of stringed instruments. It is for beginners to music educators. [9]



Fig. 2.4 TonalEnergy App Icon



Fig. 2.5 TonalEnergy Mobile Application Screens

An individual can use this application to improve listening skills for different note sounds. One can sync their instrument sound with others in ensemble with this application. This makes the app notable.

Playing with a selected note helps to mainly concentrate on a single note. It shows smiley faces if the pitch is perfect which make this application a fun game. Various type of signals are generated based on the instrumentalist frequency to play a pitch/note.

Although the app provides meaningful assessment features, it doesn't provide guidance on fingering and tuning techniques.

2.3 Fingering Charts Pro Application

To play an instrument, fingering play a key role. With a proper fingering technique one can easily tune the given note. Fingering Charts Pro gives these alternate fingering for brass and woodwind instruments. This application shows fingering for 21 instruments which is easy to understand and navigate. Here the concert pitch is played while we drag and click the note on the instrument shown on screen.[8]



Fig. 2.6 Fingering Charts Pro App Icon

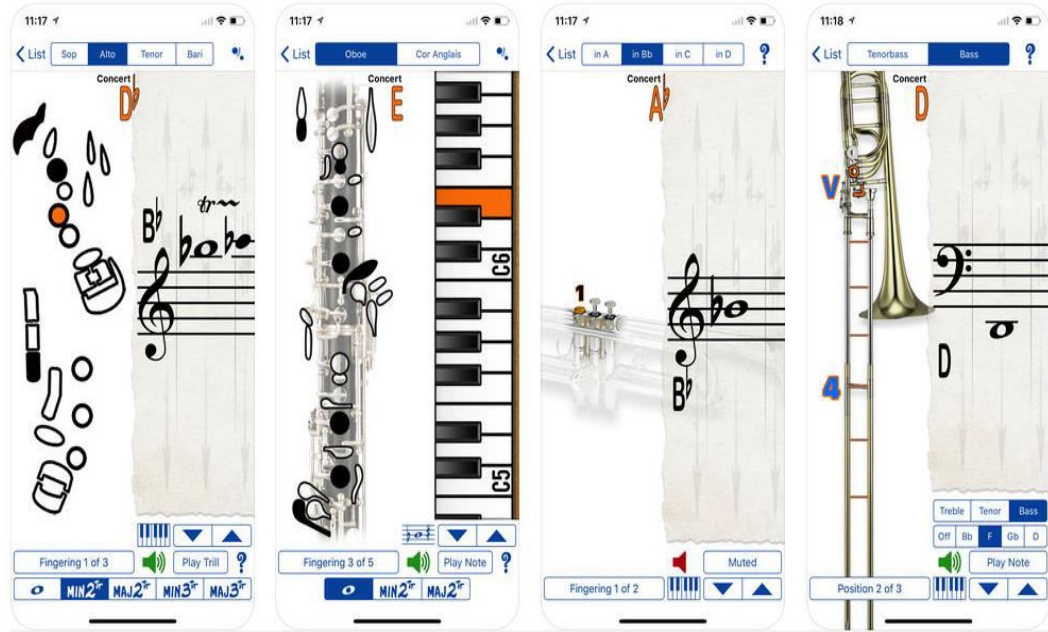


Fig. 2.7 Fingering Charts Pro Mobile Application Screens

However, the app doesn't provide any assessment capability that give learner feedback. The app is also difficult to navigate due to its complicated layout, which limits its usage as a potential learning tool.

2.4 Smart Music – iPad Application

Smart Music application is mainly designed for iPad users that can be used for private lessons and classes. It has a tuner, fingering charts, metronome and can also provide quick assessments.

Smart Music allows teachers to create classes, to assign assignments for students and to create practice sessions. It has many books related to music and solos with accompaniments.

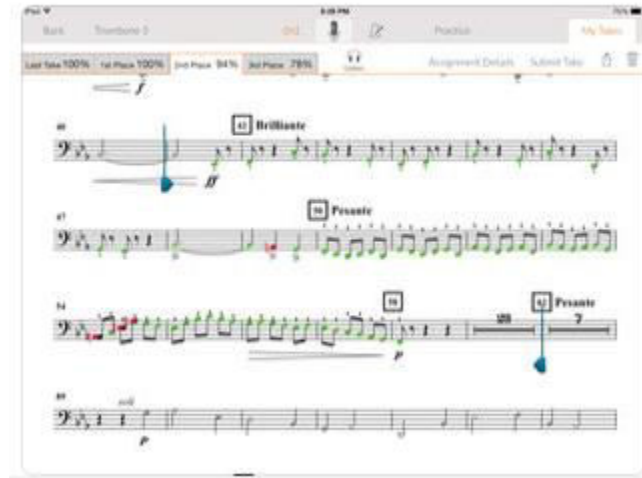


Fig. 2.8 Smart Music App Icon and iPad Screen

This application also allows students to record their performance and they can send to their respective teachers for assessment. This is an award-winning application in 2014 for Best Concert Band/Orchestra Teaching Tool. It gives the assessment to the students where to improve and scores to improve their confidence based on their performance. [12]

However, it is intended for advanced lesson and practices for experienced musicians instead of for early learners.

2.5 Cleartune Application

Cleartune is a user-friendly application that is designed for the beginners. It has a big display, so that everyone in the room can see that in a glance. It has pitch and temperament settings. Selection of tone waveform is available. However, it doesn't provide guidance on fingering and tuning techniques. [13]



Fig. 2.9 Cleartune App Icon and Mobile Application Screen

2.6 Tunable Application

Tunable starts calculating instruments pitch from a very low range than Cleartune. It turns the screen green if instrument player is in right tune, which gives a self-assessment and a clear picture of their performance. [14]



Fig. 2.10 Tunable App Icon

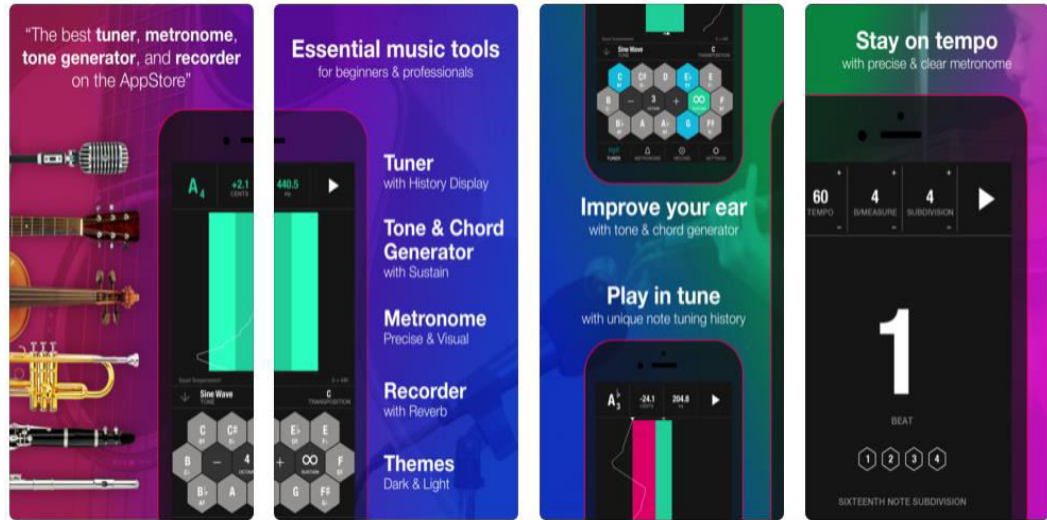


Fig. 2.11 Tunable Mobile application screens to show its mechanism

This application has wide variety of operations, like recording, generating the tone, calculating the pitch (i.e., tuner) etc.

2.7. IStroboSoft Application

It is simple but has an accurate and precise tuner. Reacts to wide range of pitches and use a mic if required.



Fig. 2.12 IStroboSoft App Icon

IStroboSoft application is helpful to tune and show the assessment for a single instrumentalist. This application shows the note in a generous size, which give a clear view. Here it automatically changes the transpose notes up and down to full octave.

Different type of signals can be used to see how the frequency is varying [15].

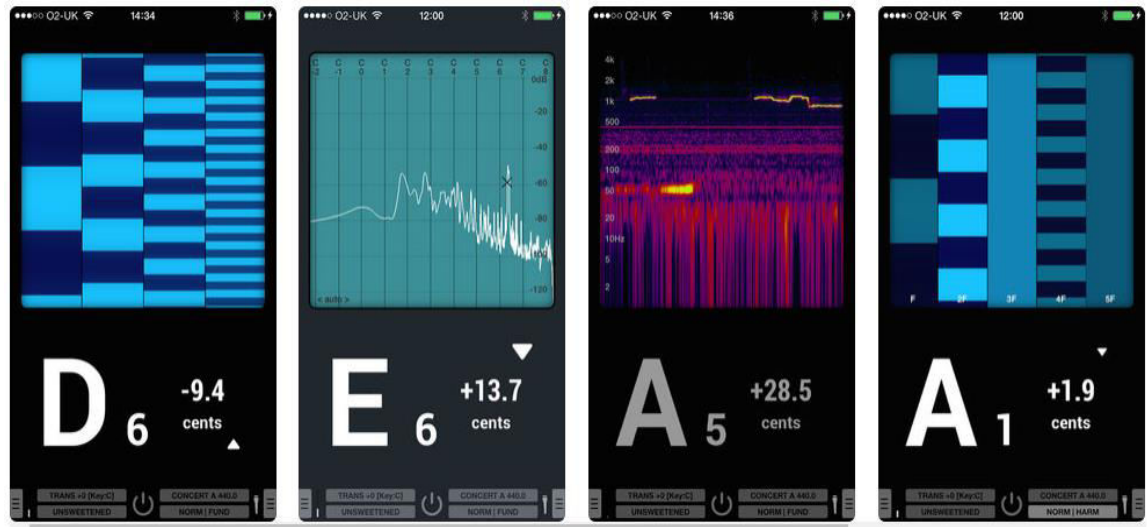


Fig. 2.13 iStroboSoft Mobile Application Screens to show its mechanism

In summary, there are many applications in app store. Above mentioned applications are among the best applications for music learning. It is clearly evidenced that none of them offer comprehensive instrument learning experience for beginners or as refresher for experienced musician that provides sufficient guidance on fingering/tuning, accurate assessment/feedback on performance, and easy-to-navigate access.

Our proposed Fingering and Tuning iOS application provides quick access to notes and we can scroll through fingering chart with ease. For notes with more than one type of fingering, there are options to choose and select the easiest one that user can use. As these fingering images are obtained through research from the best in the profession, it helps the beginners to get in tune accurately and easily.

Instrument with fingering chart and notes also provide buttons that explain about the tuning chart, Keys chart and information regarding the instrument etc. When an instrumentalist is ready to practice, by selecting the tuner button, a small but easily-

readable assessment panel shows the tuning of the performance compared to the selected note. It samples and calculates the instrument's pitch, and compared to the pitch of that note. If pitch matches and stay between a close range from the note frequency, then the screen turns green, indicating that instrumentalist's performance is good. If it ranges between some satisfactory ranges from the note frequency, then screen turn yellow, indicating that instrumentalist's performance is acceptable but can be further improved. If the range is too far away from the note frequency. Screen turns red, indicating that the performance is not acceptable, and correction of fingering techniques may be required.

Furthermore, after the users complete learning individual note, they can go to the next-level to practice a sequence of notes. Our app will show the constant pitch change and identifying the corresponding notes when instrumentalist starts playing the instrument.

3. IOS APPLICATION DESIGN

IOS is a mobile operating system that is designed and developed for iPhones, iPod, iPad and tvOS by Apple company. It is an evolving platform with new features and innovative capabilities added all the time. Its usage and economical and social impact are hugely amplified by its millions of apps. So, there will be apps at your fingertips every time. In this thesis, we explore the iOS platform for enhancing music education and learning experience through mobile app design.

For creating applications for iOS there are mainly two languages:

1. Objective-C
2. Swift

Early iOS developers used Objective-C because it is just like C and C++. This is a user-friendly language that is easy to understand and easy to code. But after Apple introduced Swift in 2014 and made as open source in 2015, then most of the developers turned towards swift. It is a language for new generations. In this research, we use Swift for the app development.

Swift can run along with Objective-C, C, C++ in one program except in Linux. It is included in Xcode since version 6. This is an interactive, multi-paradigm, and general-purpose programming language that has playgrounds to play with, while programming.

3.1 Swift Programming

Swift first started its journey in 2014, after that it underwent many version changes. As Apple started experimenting with Swift, it made Swift to support many core concepts that associated with Objective-C. It made Swift to catch software bugs in an easy way. Apple neither compromised with performance nor development with ease. Swift is an excellent choice for new programmers. Because it is new, developing with great features and more popular in the outer world. Some important features of swift are given below:

1. Fixes software bugs immediately
2. Gives recommendations while coding
3. Finds the duplicated code instantly
4. Initialization of variables is done before use
5. Accordingly, memory management is performed
6. Simulation is quick

Version compatibility seems a problem sometimes while running apps on Xcode. So, a programmer should be up to date with version updates. Swift 4 or Swift 3 can be used to run on Xcode 9.2 or greater versions.

3.2 Getting Started with the Application Development

It started with getting the latest version of Xcode from Apple App Store.

1. Go to app store on Mac

2. Search for Xcode and set the latest version of Xcode for download/install.
3. App store may ask for your apple Id sometimes depending on your settings, type your apple id and set install.
4. Now go and check in application directory for Xcode.



Fig. 3.1 Xcode App Icon in Application Directory

Before getting started with Xcode, choose the language that is going to be used. Start with playground in Xcode to learn if it is a beginning stage. Developers who already played with playground directly starts with creating the new project.

3.2.1 Xcode Project

1. Create a new Xcode project.



Fig. 3.2 Xcode Window to Create a New Project

2. Select iOS at the top from iOS, watchOS, tvOS etc

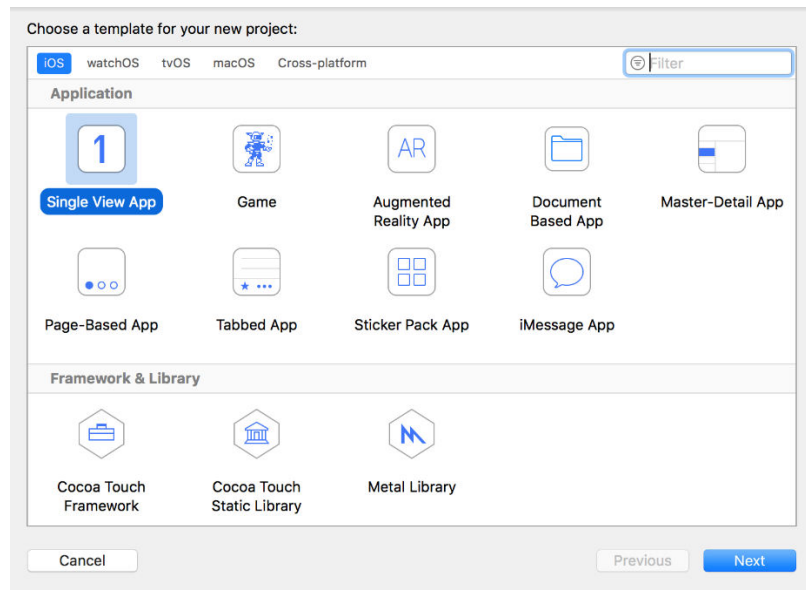


Fig. 3.3 Selecting a Template for New Project

3. Select the single view application, then next
4. Now enter the name of the project and organization name, if available and select the language as swift.

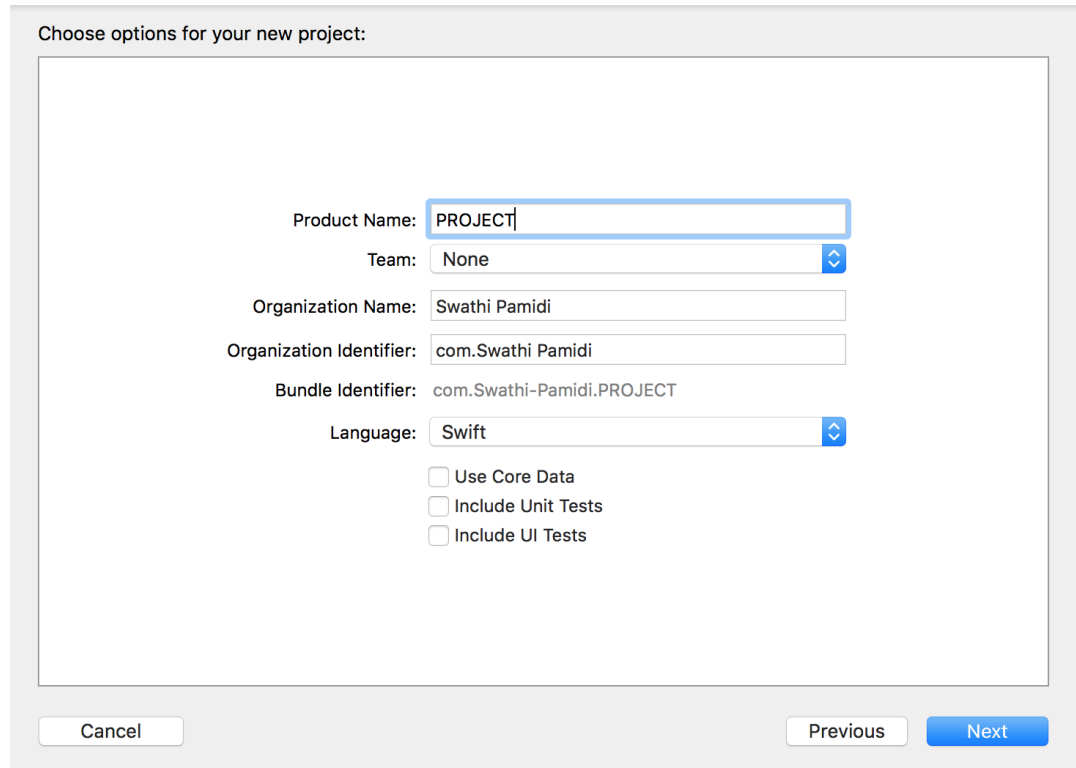


Fig. 3.4 Choosing Options for New Project

5. Unselect all the three options down there and proceed to create the project.

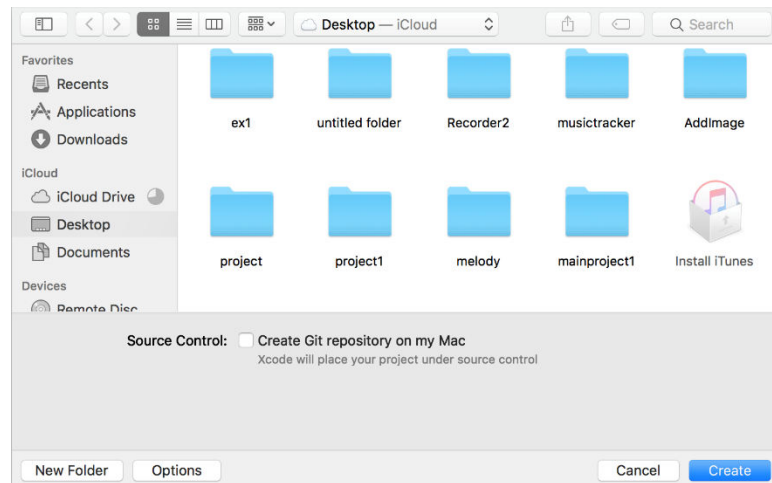


Fig. 3.5 Selecting the Browser/Folder to Create a project

Finally created an Xcode project, there will be an error, if you haven't provided a team, don't worry about it. Now run the application. In the simulator a white screen is appeared as a default window.

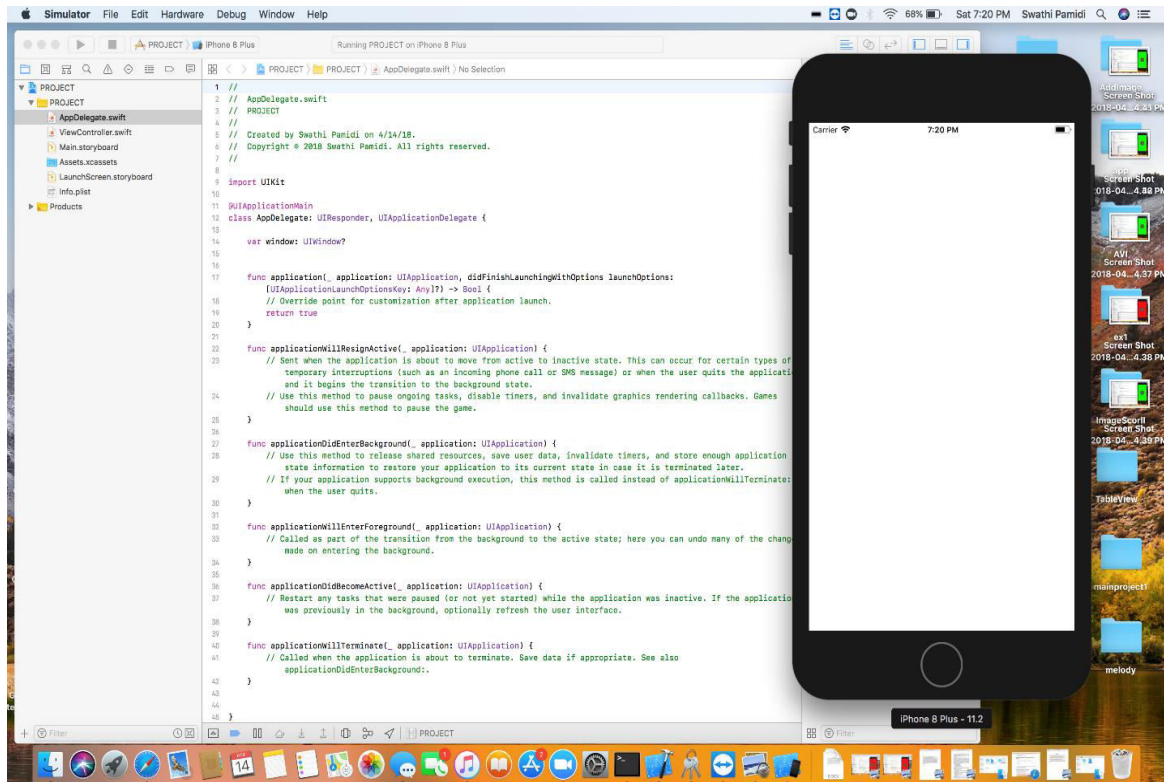


Fig. 3.6 Create a New Application

3.3 Application Design for Music Instrument Learning

Let's get started with the programming. Fingering and tuning iOS application as a default UIKit is used. This is a framework that offers an infrastructure for iOS applications. These are developed by Apple to make the developer life easy. This allows the developer to create a window and view architecture for our interface design. Usage of button actions, image view, text bars, scrolling etc. Can be created and used in our

interface with this framework. This framework also offers painting support, document support and data management through text files or JSON file etc. This creates the blocks by which developer can create a building. In this application Audio Kit framework is also used to take the audio from the microphone and related operations. Let us discuss this in the upcoming topics. To include these frame works in code use the command lines given below:

```
import UIKit
```

```
import AudioKit
```

3.3.1 Data Management

Here data management is very important, because there are many images all around. For fingering, notes and their detailed information. In general, data management creates an easy path for an application developer. While processing, adding or editing the data in to the application is just like picking up a candy from a bowl.

In this application the user data that is related to application is collected in JSON file as 'MetaData'. For a single instrument it is easy to embed and access the data directly from the code. But for more than one instrument for expandability, it demands more flexible data management. It is also better to run the application without requiring loading data for all instruments, as it is waste of memory and compilation time. Thus, managing a huge data is a critical and challenging task while creating an application.

This data management can be done in various forms with .txt files, .json files, or .xml files. Here, JSON files comes in handy. All the data is organized for each

instrument accordingly one after the other. So, when we first include the file and run the application it loads only the required data (i.e., single instrument data). This is also useful when there is an error in one instrument data will not affect other instrument.

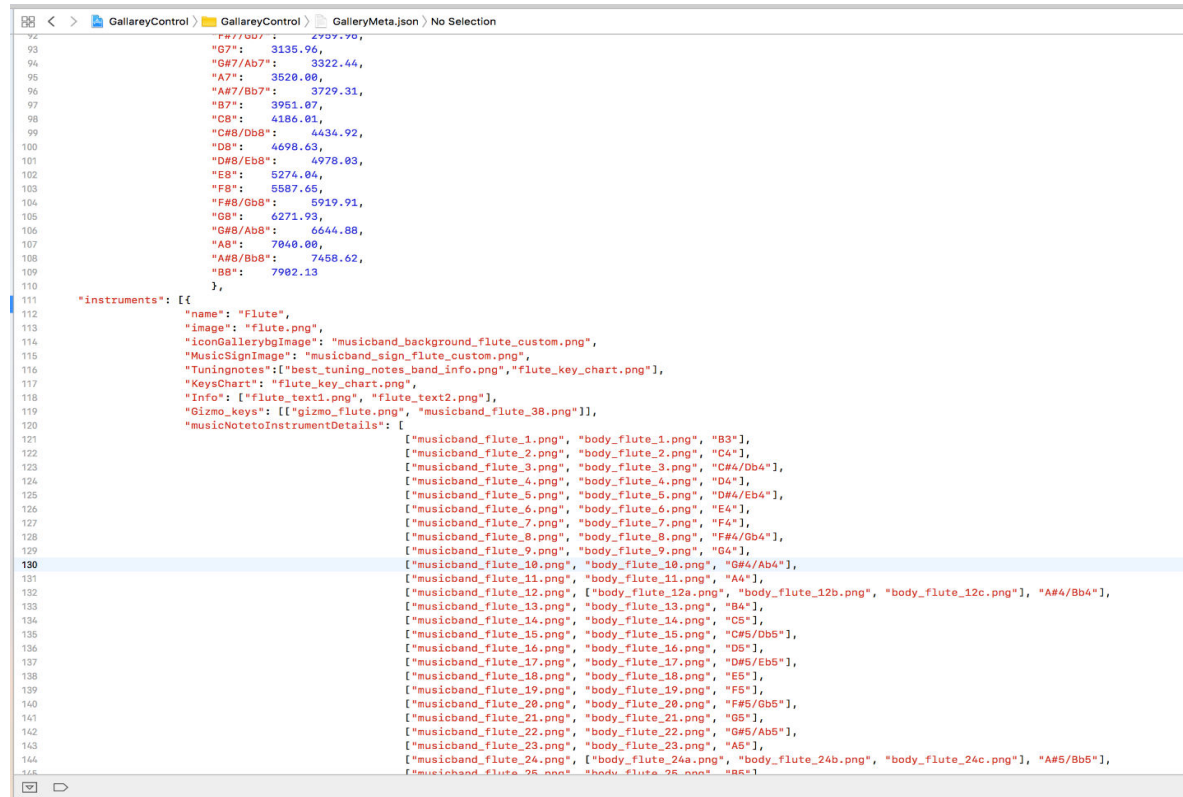


Fig. 3.7 Arranged Data in JSON file for IOS application

3.3.2 Navigation Area

Now let's start with the navigation area. This area provide fast browsing of notes and navigating to access the desired fingering/tuning chart file. All the program files, pods, frame works, etc. are listed in this navigation area. This is like a manager giving instructions to the team leader (files). The team lead carryout and distribute the work in their team and after completion the work is transferred to the next team according to the managers instructions.

First, let's talk about the LaunchScreen.storyboard. It loads an image to a screen while the app gets loaded. This is a very useful mechanism, while the app loads in to the phone this screen pops up and keep the user busy for some time. This helps as a best strategy to not to lose the users attention even for a second.

Secondly, Assets.xcassets in navigation area is used to store all the image files that are used in the project. It already has an inbuilt App Icon folder which is empty. Here load the app icon images. They have various sizes based on iPhone and iPad sizes.

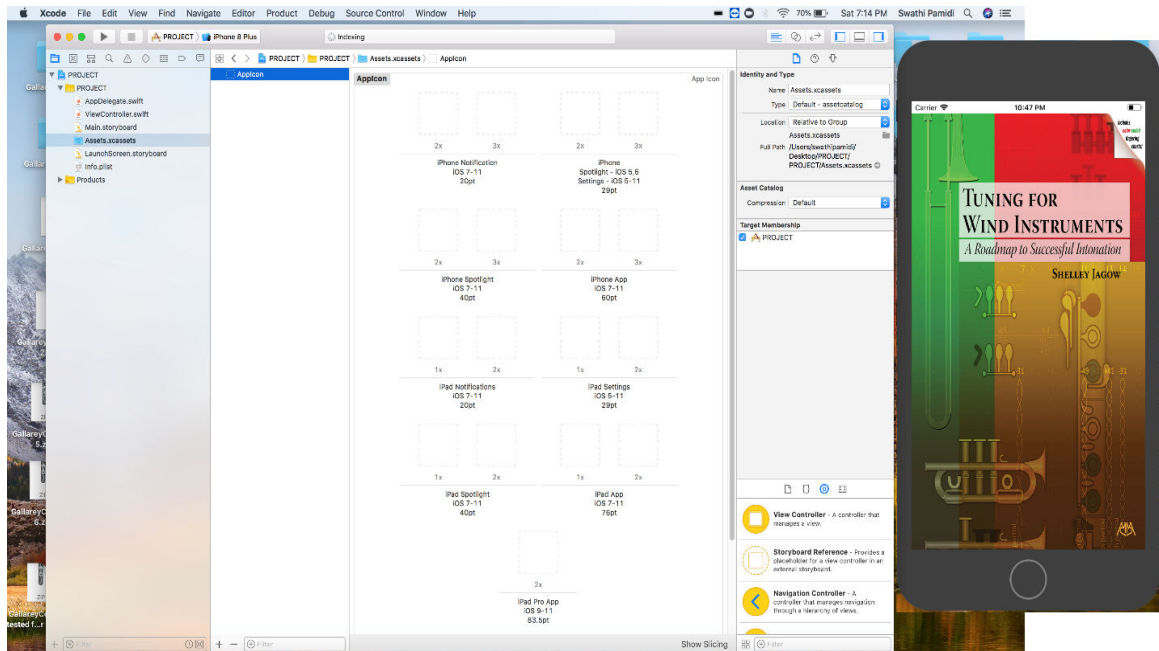


Fig. 3.8 App Icon Sizes in Xcode in Left and Launch Screen Window in Right iPhone Simulator

Thirdly, there is Main.storyboard already has a window where we can bring the required button views, text fields and image views to fill the screen. But the constraints to be stated properly, action should be performed, and related code/instructions should be written. So, to make the code reliable and work on all type of devices, let's create a

window in the AppDelegate.swift file through code. This helps application to run iPhone and iPad according to the instructions given in code. Because Xcode gives much importance to the code rather than the things carried out in main.storyboard.

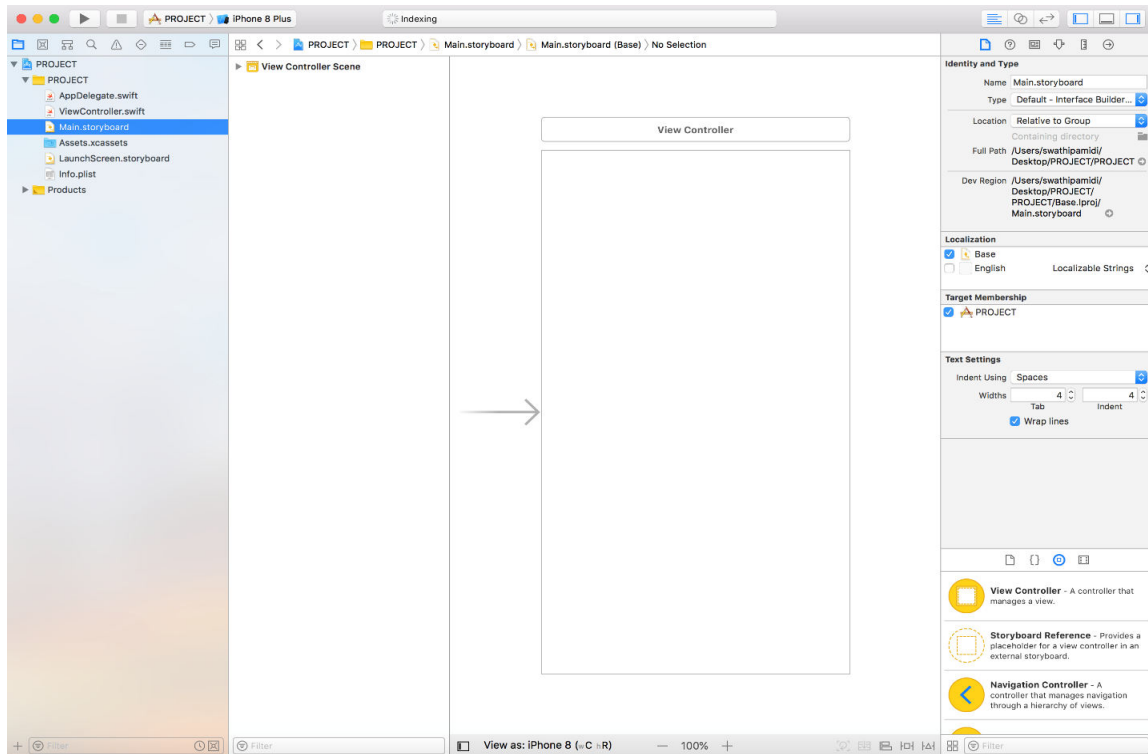


Fig. 3.9 ViewController in Main.storyboard for Designing Application

3.4 Designing Screens for Application

Creating different Viewcontrollers enables us to have different screens while selecting distinct options.

3.4.1 Instrument Selection Screen

After the launch window, there comes the initial window. All the ten instruments in the application are present here. While scrolling down there comes more instruments. Here UIScrollView is used for scrolling vertically up and down. Button views are used to set the instrument image as background and performs action when clicked.

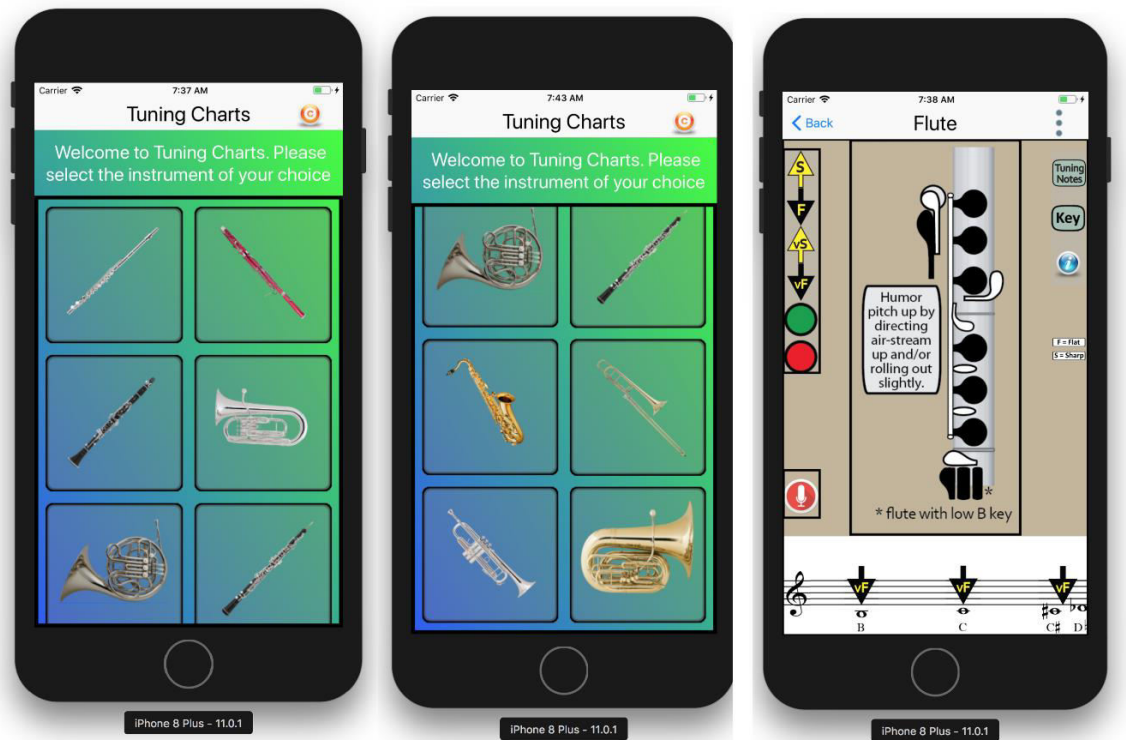


Fig.3.10 Application Screens, left two show the initial screen and the right one shows the second screen after selecting an instrument (Here Flute is selected).

Selecting one instrument by clicking the buttons present, this takes to the next window where all the note images and detailed fingering images are displayed. Here gradient color is used as a background color to give the 3-dimensional look to the screen.

3.4.2. Detailed Instrument Fingering Screen

This second screen looks like the Fingering and Tuning Charts android application. As motivation for both the application is taken from the same book. But this application adds extra features. The Intonation meter is added for assessment of the note frequency. Moreover, series of notes can be obtained while playing an instrument for tune.

Bottom there are notes which can scroll from right to left and left to right with ease. So, one can easily scroll along and can find the note they want. Towards the left of the notes there is a music sign image, that changes based on the instrument and remains at the same point, even though the notes move along.

Top of the note, there are detailed fingering images of the notes specified at the bottom. This also has a scroll view with paging. These two scroll views of notes and detailed fingering images are synchronized. So where ever you select note you get the respective detailed fingering image. That is if we scroll the notes and select A4 note, then A4 note comes to center and its respective fingering image is shown on the top scroll.

3.4.3. Alternate Fingering Options

Here in the above figure one can observe the there is a sudden pop up of option buttons. This comes for the notes that have alternate fingering. Always the regular fingering is seen as option 1. To get the next fingerings select other options. This helps user to get the broader view and alternate fingering help user to choose among them, that is which fingering to use.

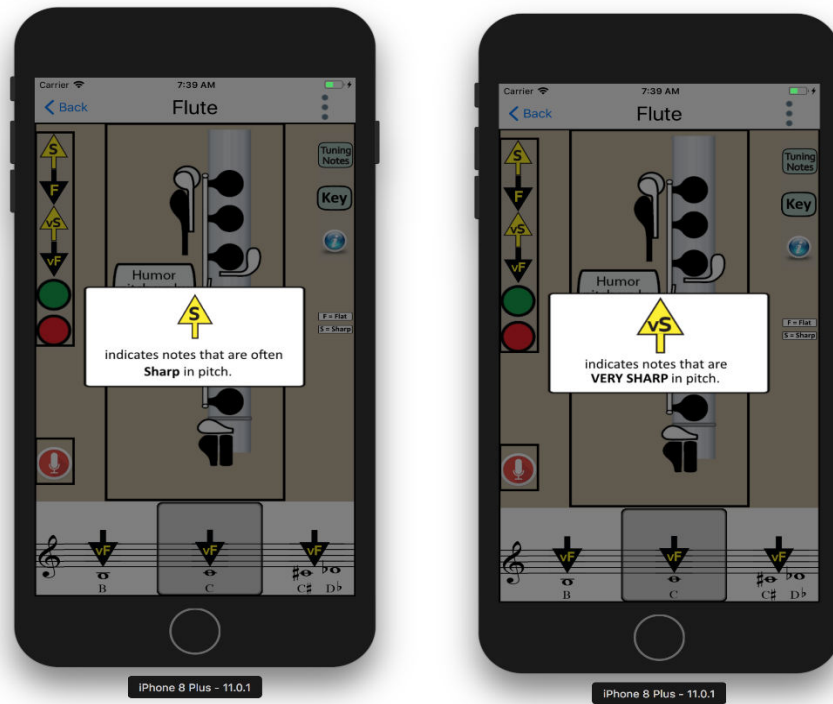


Fig. 3.12 Screen Showing pop up for Left side bar Buttons



Fig. 3.13 Screens Showing pop up for Left side bar buttons

3.4.5. Right Button Clicks

Below Image is tuning notes pop up image for an instrument. Click anywhere to go back.

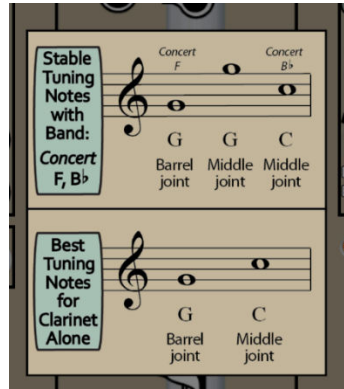


Fig. 3.14 Tuning Notes pop up Image for Instrument Clarinet

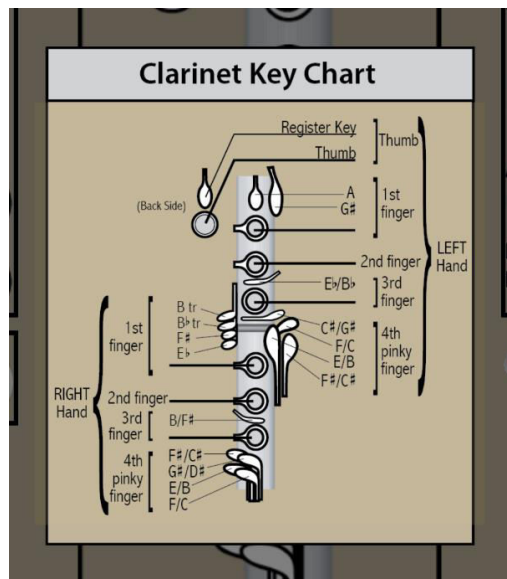


Fig. 3.15 Clarinet Key Chart

The above image shows the Key chart for instrument clarinet. This gives the detailed information about the instrument. For beginners this helps to improve their knowledge about the instrument.

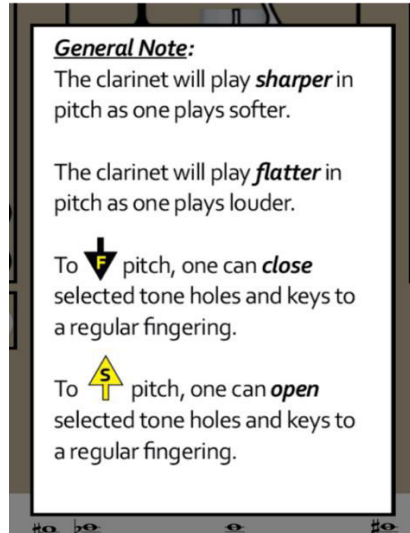


Fig. 3.16 Info Button Click pop up for Clarinet Instrument

This info button gives the general information about the instrument and its usage. There are two text fields in which one shows that ‘S’ means Sharp Pitch and other shows that ‘F’ means Flat Pitch.

3.5 Intonation Meter

On the left of the screen there is tuner button in between top left bar button and music sign image.

When Tuner button clicked once: It opens a small pop up window down there itself. It opens the meter which measure the intonation of that selected note.

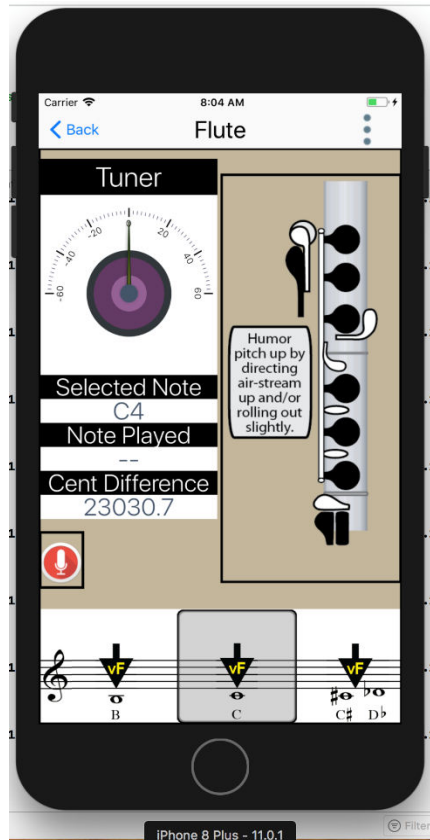


Fig. 3.17 Intonation Meter (Tuner)

This meter helps the instrumentalist to learn a single selected note in an instrument. Intonation meter two things are involved:

1. Intonation Meter view
2. Frequency /Pitch calculation
3. Mechanism Applied in this application

3.5.1 Intonation Meter view

First let us discuss about the Intonation meter view. This view is like the Partita instrument tuner application view, present on git hub [6], an open source project under

the MIT license. But the complete Partita instrument tuner application using AudioKit 3.0 or higher version is not necessary for our application. However, we believe a meter-like view help illustrate the cents difference from the selected note with the needle to move accordingly.

WMGaugeView is used from this partita application for our meter view. Based on the cents difference the background color is changed to make it more fun. Also, for better indication of performance.

3.5.2 Frequency/ pitch Calculation

Pitch calculation is very critical thing in this application. We referred to the ‘guitar tuner application’ from git hub [5], an open source project under the MIT license. This application uses Audio Kit 2.2 version, which our application is using. This application has the note, pitch and tuner files that allows the mic to record. Pitch calculation is done using the mathematical formula and their respective notes are connected to them. This calculates the concert pitch.

Install cocoa pods in application: Cocoa pods [11] act as a dependency manager for objective-C language. It has thousands of libraries that will scale our project sophisticatedly. So, one can use third party open source code profitability in their applications. These help the project to be up to date all the time. Pods contain some instructions in a single line, that has dependencies and these cocoa pods resolve the dependencies in libraries and fetch the data from the source code link them to the project to work.

3.5.3 Mechanism Applied in this application

Here the frequency recorded is calculated by using the tuner file. This frequency is taken as the recorded frequency. Already from the meta data selected note frequency is taken from the data. This both frequencies are compared to get the cent difference.

$$\frac{f_2}{f_1} = 2^{\frac{c}{1200}}$$

Fig. 3.18 Formula to Calculate Cents

Here from the above formula, take f_2 as selected note frequency and f_1 as recorded frequency C as Cents. Thus, the cents difference can be found by taking the selected note frequency as reference.

If recorded frequency is less than selected note frequency needle goes towards left showing it as negative cents. So, to improve one must increase their frequency/pitch. If recorded frequency is greater than selected note frequency needle goes towards right showing it as positive cents. So, to improve one must decrease their frequency/pitch.

Here the scale/meter is divided in to -60 cents to +60 cents. When cents difference compared to selected note frequency is between -5 cents to +5 cents the screen turns green. When the cents difference compared to selected note frequency is between -5 cents to -11 cents or +5 cents to +11cents the screen turns yellow. When the cents difference compared to selected note frequency is less than -11 cents or greater than +11cents then

the screen turns red to show that the performance must be improved. There is also a label that shows the cent difference from the actual selected note frequency.

When Tuner button clicked twice:

This opens a new window/ screen which shows the continuously varying pitch when the user plays an instrument with different notes. A note will be taken as the middle node and the scale is divided from -50 to +50 from C_0 to B_8 accordingly. C_0 starts at -50 and B_8 ends at +50.



Fig. 3.19 Intonation Meter to Get Series of Notes while a Instrumentalist Play an Instrument

4. EXPERIMENTAL STUDIES

In this chapter, we will focus on the correctness of the app design, implementation and operation as well as accuracy of the performance assessment of intonation practices and will illustrate through screenshots of the results that we have obtained through our experimental studies.

4.1 Loading Data for a Specific Instrument (In iPad view)

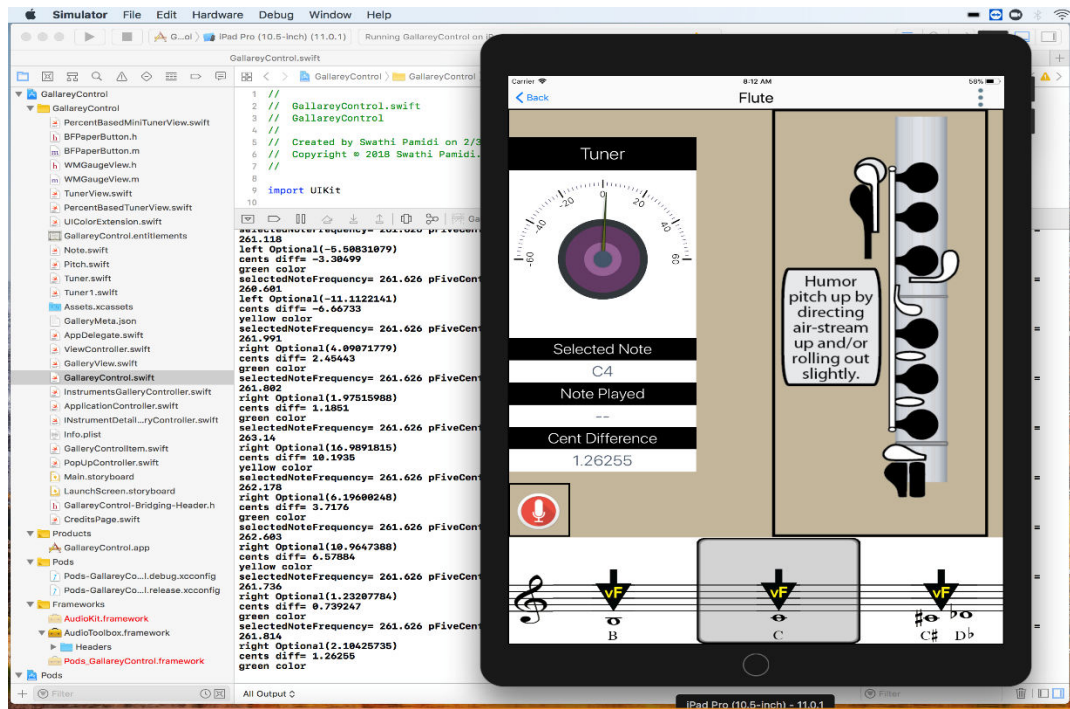


Fig. 4.1 Instrument selection: when the Flute instrument is selected, its respective notes and fingering images are loaded in to the application.

4.2 Performance Evaluation of Intonation Meter:

In Fig. 4.2, the selected pitch is C4, we can see that the cent difference is less than -5 cents. So, the screen turned green to indicate good intonation.

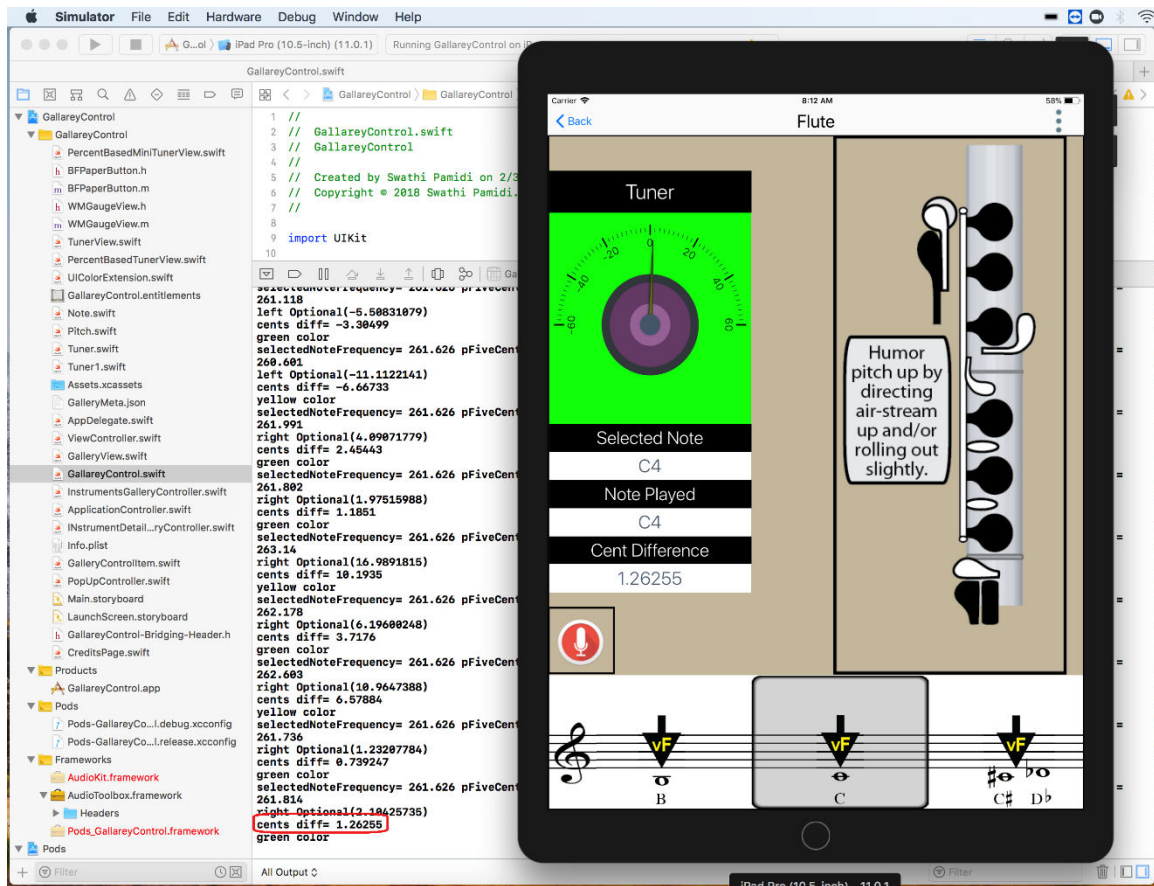


Fig. 4.2 Simulator output screen 1

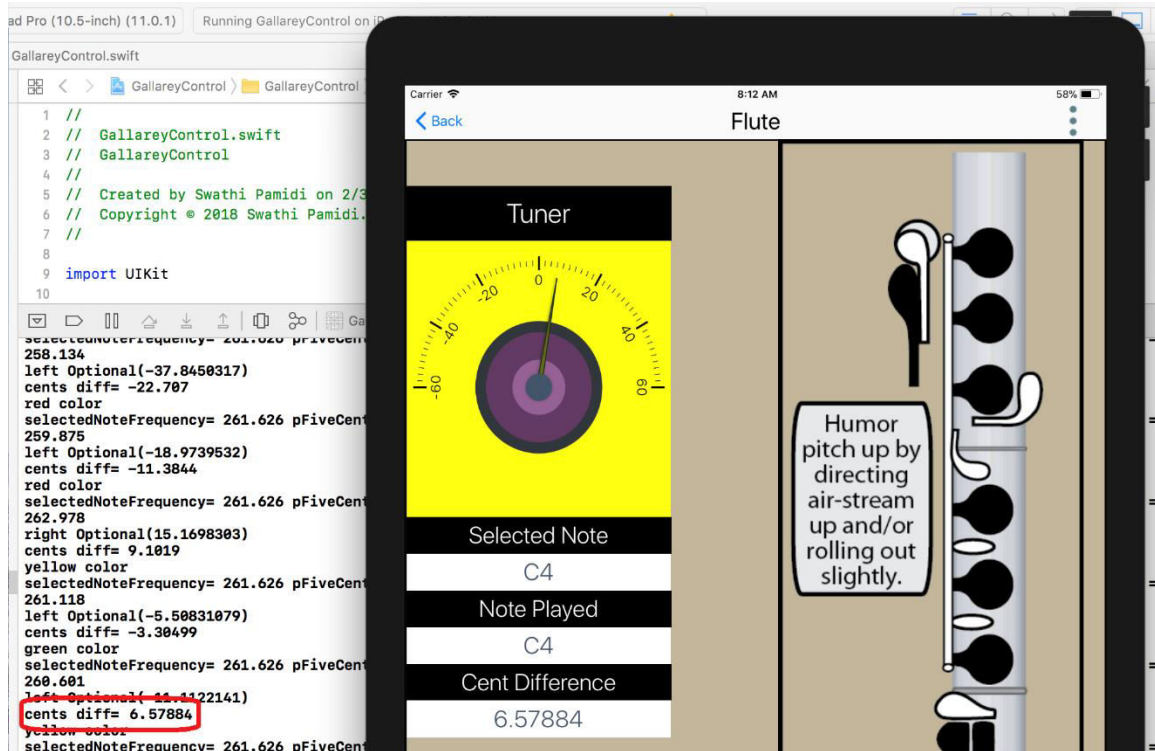


Fig. 4.3 Simulator output screen 2

Next, the selected pitch or note is C4 , in the screenshot shown in Fig. 4.3, the simulator screen turned yellow because the cent difference is more than -5cents and less than -11 cents, indicating performance that is acceptable but need further improvement.

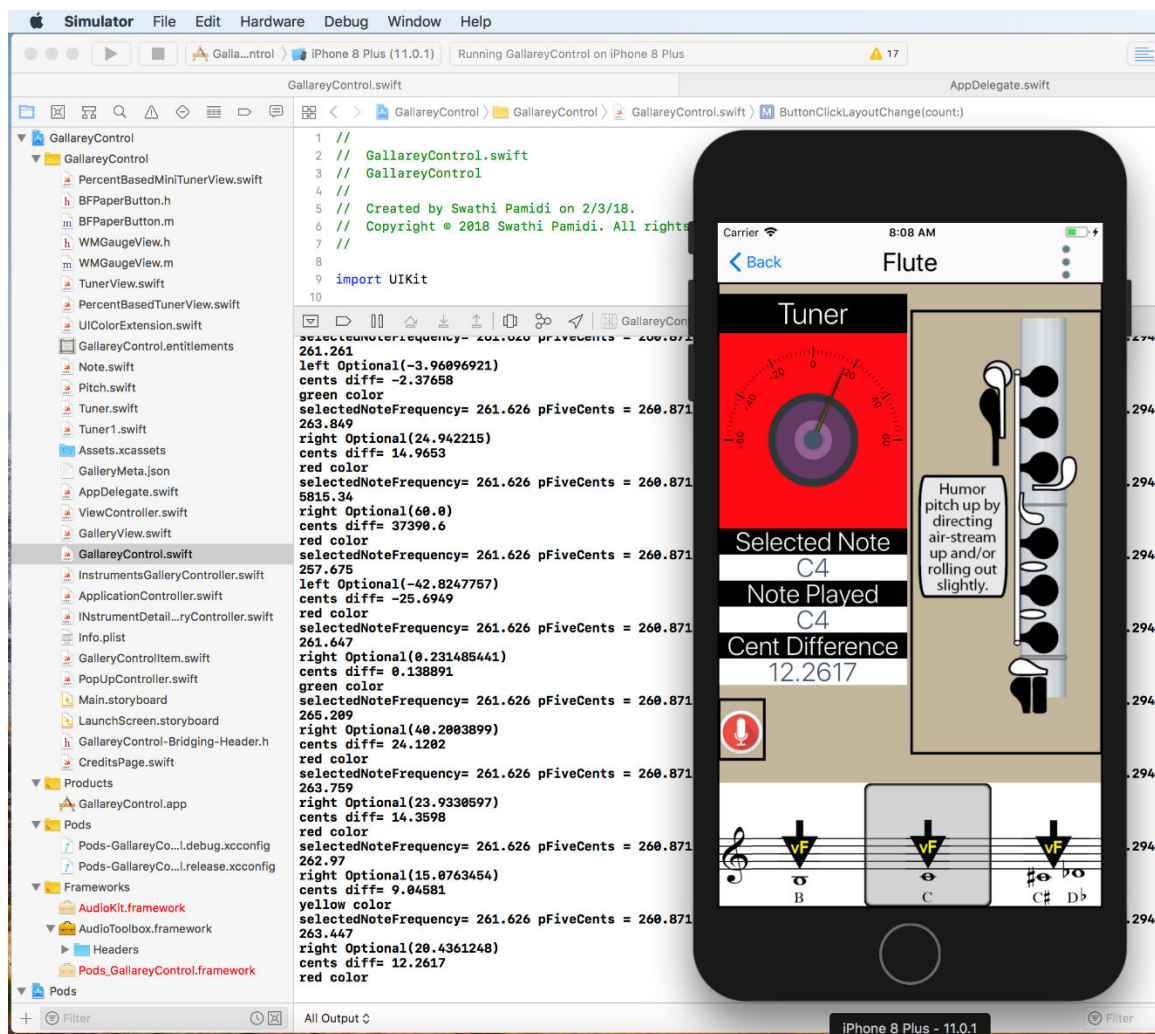


Fig. 4.4 Simulator output screen 3

Next, the selected pitch or note is C4, in the screenshots shown in Fig. 4.4, the simulator screen turned red because the cent difference is more than 11 cents to indicate lacking performance.

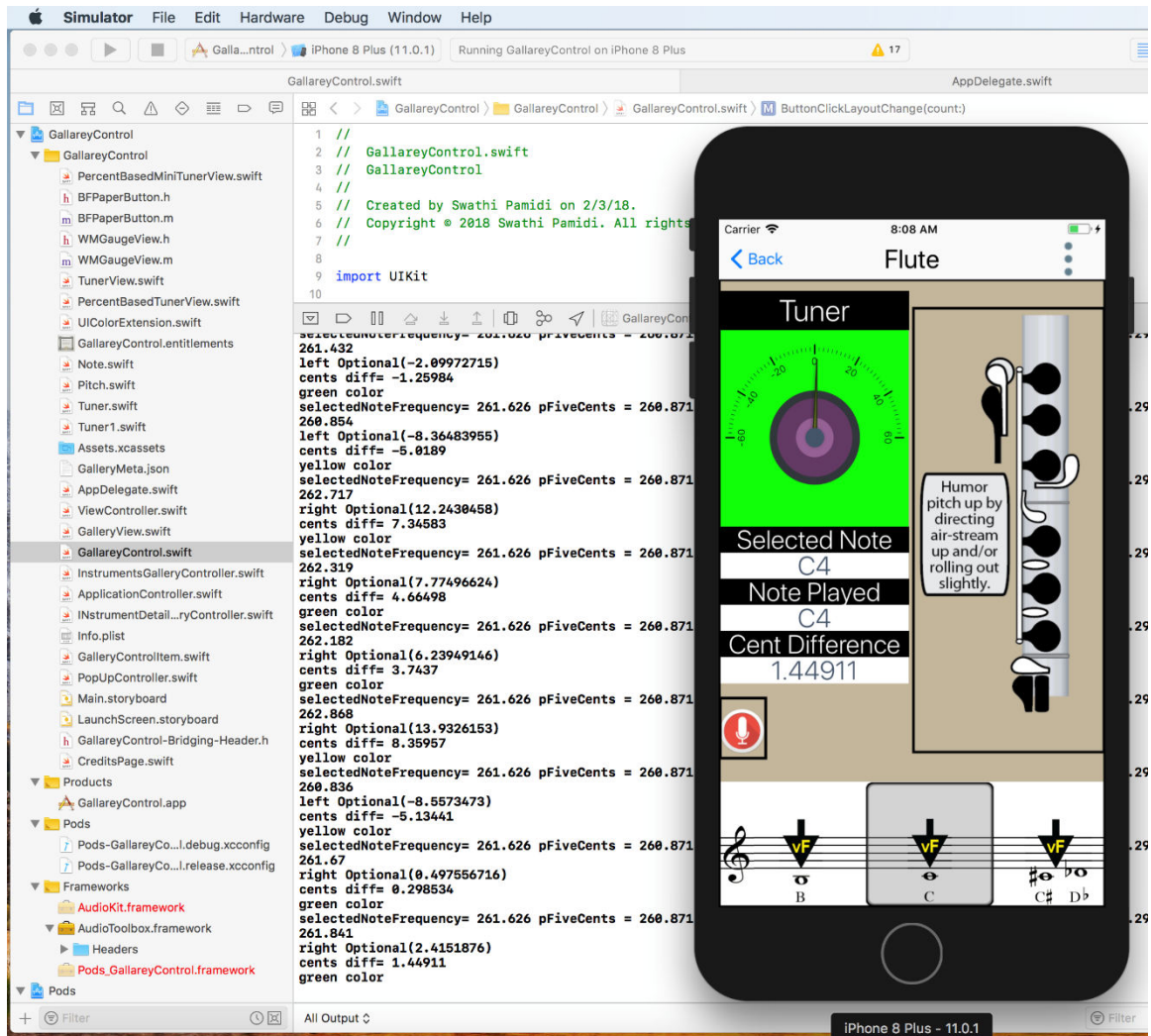


Fig. 4.5 Simulator output screen 4

Next, the selected pitch or note is C4, in the screenshots shown in Fig. 4.5, the simulator screen turned green because the cent difference is not more than -5cents to indicate superior performance.

4.3. Performance Evaluation for Series of Continuous Notes

The intonation meter is showing continuously the sequence of notes while the instrumentalist plays as shown in Fig. 4.6 and 4.7.

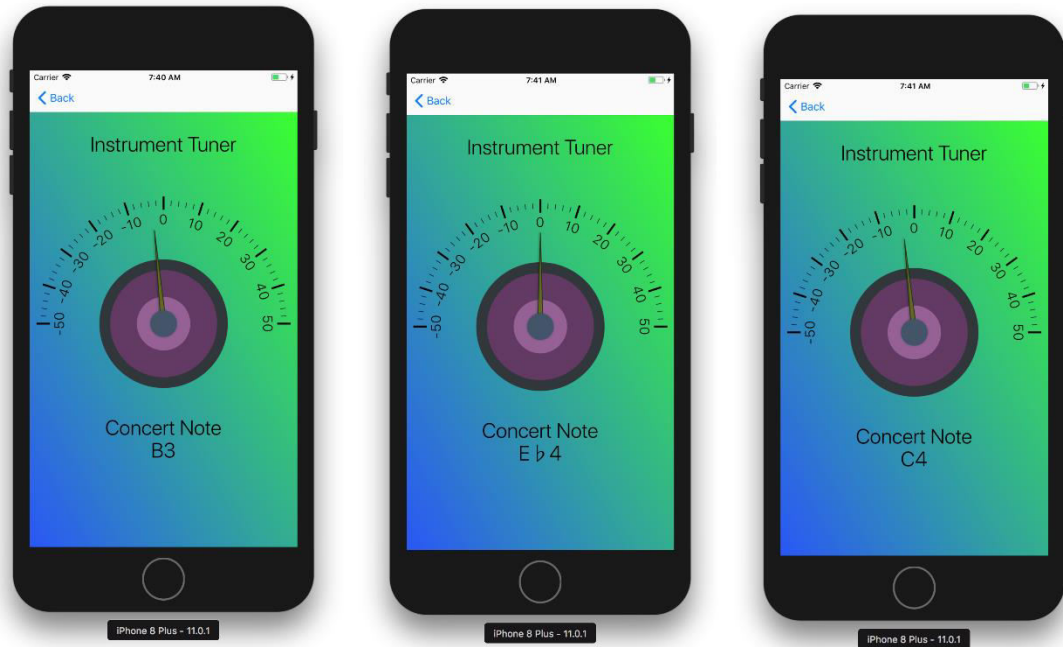
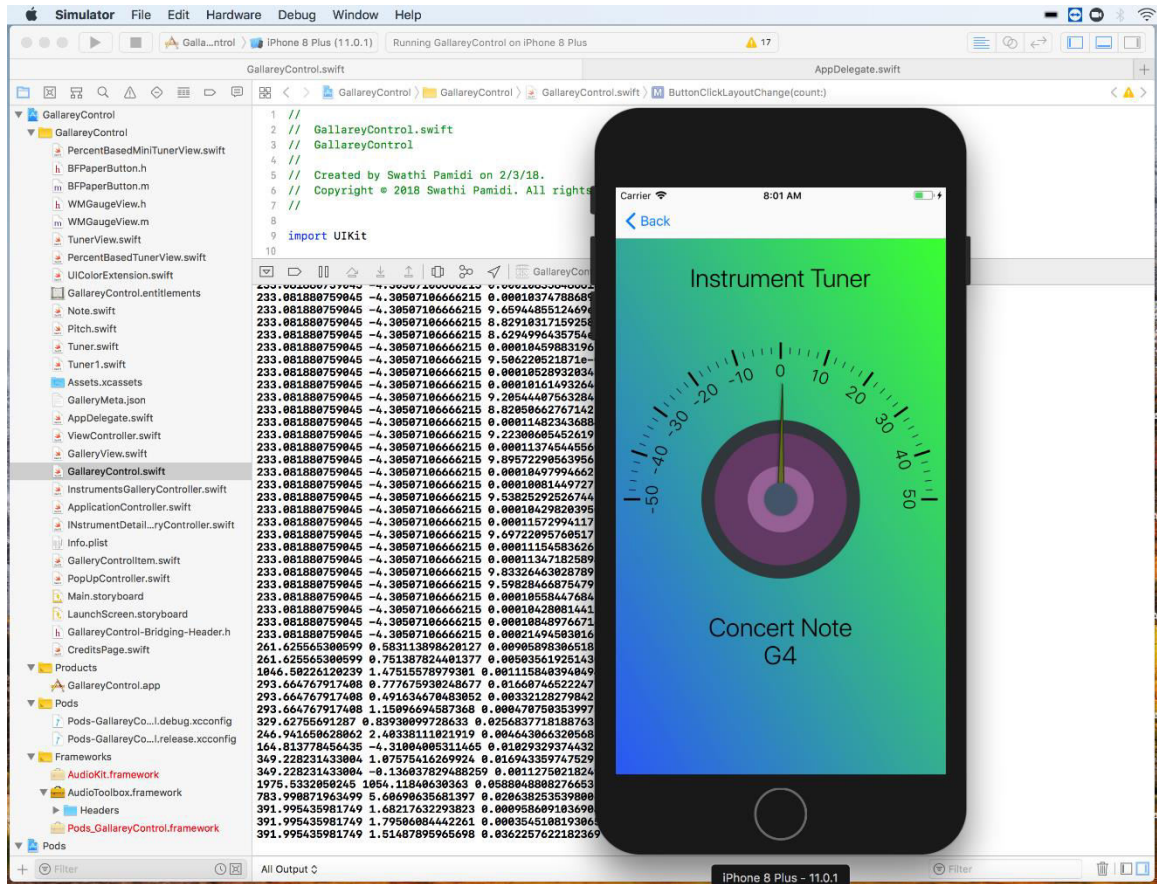


Fig. 4.6 Simulator output screen 5- series of continuous notes



4.7 Simulator output screen 6

5. CONCLUSION AND FUTUREWORK

5.1 Conclusion

Learning music instrument is a challenging task for a beginner without constant guidance from an instructor. This proposed application help user to learn a suite of wind instruments by themselves with comfort and ease. This gives the chance to get perfect pitch and practice tremendously being in comfort zone with app-assisted self-assessment.

This helps music instrument learners to improve their skills without regular monitoring of a professional person around them. To cope up with the ensemble this application helps a lot to determine their pitch and learn the fingering and to play correct notes. The series of notes help to determine how an instrumentalist tune their music with the instrument.

Design and Implementation of Fingering and Tuning Charts Application in iOS is performed successfully in this thesis work. Particularly, our app provides the following features to enhance the user's learning experience:

1. The app provides learners easy-to-access information for the fingering and tuning techniques of wind instruments by converting Dr. Shelley Jagow's popular book – "Tuning for Wind Instruments: A Roadmap to Successful Intonation" to an iOS app.

2. It provides instant feedback on learner's technique and performance by assessing the pitch of individual note being played, while the fingering and tuning chart is presented for the early practices.
3. It also provides instant feedback on learner's technique and performance by identifying the sequence of notes being played for subsequent practices.

5.2 Future Developments

Technology is growing from day to day, there are more than limited options to improve this app. The following could be a few particular interesting features to have for a more comprehensive music instrument education/learning experience:

1. Most of beginners don't have a proper ear training. So, in the beginning they struggle a lot for tuning or to obtain a correct pitch. If proper guidance is not provided this may cause a big problem in future. So, inserting audio clips for every note can improve the application usage. It also deals with the one who has poorly trained ear to improve their hearing.
2. Learning always comes with testing their performance from time to time. Practicing everyday improves the instrumentalist performance. But taking few tests and doing better in them increases their level of confidence. These tests can be designed exactly like a game that will refresh and recharge their energy. This can be made fun, setting goals to upgrade to new levels, and comparing with the professional performers in real time will encourage the learners.

3. Few instrumentalists don't get a proper pitch or tuning even after lot of practice. This might be because of using poor warm up sessions, instrument quality, bad posture or position, being too far or too close. There are numerous reasons why an instrumentalist's performance is degrading or disruptive in the band. Thus, they require a proper feedback for their performance more than pitch detection.

In future by using machine learning, pose/motion analysis, augmented reality techniques in application, more comprehensive feedback can be produced for their improvement in performance.

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